

WHAT IS CLAIMED IS:

1. A method for manufacturing a trench capacitor comprising:
  - defining a semiconductor substrate;
  - forming a trench with a lower region and an upper region in the semiconductor substrate;
  - forming a buried conductive region around the lower region;
  - forming a first insulating layer along sidewalls of the trench up to a level between the lower region and the upper region;
  - forming a second insulating layer along the sidewalls of the trench at the upper region, the second insulating layer being separated from the first insulating layer by an intermediate region; and
  - forming an oxide on the sidewalls of the trench at the intermediate region.
2. The method of claim 1 further comprising:
  - removing the first and second insulating layers;
  - forming a dielectric layer along the sidewalls and a bottom surface of the trench;
  - filling the trench with a first conductive layer;
  - recessing the first conductive layer to expose a portion of the dielectric layer; and
  - removing the exposed dielectric layer.
3. The method of claim 2 further comprising:

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HENDERSON  
FARABOW  
GARRETT &  
DUNNER LLP

1300 I Street, NW  
Washington, DC 20005  
202.408.4000  
Fax 202.408.4400  
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- filling the trench with a second conductive layer; and  
recessing the second conductive layer.
4. The method of claim 1 further comprising:  
forming the first insulating layer along the sidewalls of the trench;  
filling the trench with a photoresist;  
recessing the photoresist to the level to expose a portion of the first insulating layer; and  
removing the exposed first insulating layer.
5. The method of claim 1 further comprising forming the second insulating layer in an atomic layer deposition (ALD) process.
6. The method of claim 1 further comprising forming the oxide in a local oxidation of silicon (LOCOS) process.
7. A method for manufacturing a trench capacitor comprising:  
defining a semiconductor substrate;  
forming a trench with a lower region and an upper region in the semiconductor substrate;  
forming a buried conductive region around the lower region;  
forming a first insulating layer along sidewalls of the trench;  
filling the trench with a photoresist;

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recessing the photoresist to a first level between the lower region and the upper region to expose a portion of the first insulating layer;

removing the exposed first insulating layer;

forming a second insulating layer along the sidewalls of the trench at the upper region, the second insulating layer being separated from the first insulating layer by an intermediate region; and

oxidizing the sidewalls at the intermediate region using the first and second insulating layers as masks.

8. The method of claim 7 further comprising:
  - removing the first and second insulating layers;
  - forming a dielectric layer along the sidewalls and a bottom surface of the trench;
  - filling the trench with a first conductive layer;
  - recessing the first conductive layer to a second level between the first level and the upper region to expose a portion of the dielectric layer; and
  - removing the exposed dielectric layer.

9. The method of claim 8 further comprising:
  - filling the trench with a second conductive layer; and
  - recessing the second conductive layer.

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10. The method of claim 7 further comprising forming the second insulating layer in an atomic layer deposition (ALD) process.
11. The method of claim 7 further comprising forming the oxide in a local oxidation of silicon (LOCOS) process.
12. A method of manufacturing a trench capacitor comprising:
  - defining a semiconductor substrate;
  - forming a trench with a lower region and an upper region in the semiconductor substrate, the trench further including sidewalls;
  - forming a first conductive region around the lower region;
  - forming a collar oxide on and into the sidewalls of the trench at an intermediate region between the lower region and the upper region;
  - forming a dielectric layer along the sidewalls up to a level above the collar oxide; and
  - forming a second conductive layer up to the level.
13. The method of claim 12 further comprising:
  - forming a first insulating layer along the sidewalls of the trench up to a lower level of the intermediate region;
  - forming a second insulating layer along the sidewalls of the trench down to an upper level of the intermediate region; and
  - oxidizing the sidewalls of the trench at the intermediate region.

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14. The method of claim 13 further comprising:

  - forming the first insulating layer along the sidewalls of the trench;
  - filling the trench with a photoresist;
  - recessing the photoresist to the lower level to expose a portion of the first insulating layer; and
  - removing the exposed first insulating layer.
15. The method of claim 13 further comprising forming the second insulating layer in an atomic layer deposition (ALD) process.
16. The method of claim 13 further comprising oxidizing the sidewalls of the trench at the intermediate region in a local oxidation of silicon (LOCOS) process using the first and second insulating layers as masks.
17. A trench capacitor comprising:

  - a trench formed into a semiconductor substrate including a lower region and an upper region;
  - a first conductive region formed around the lower region of the trench;
  - a collar oxide formed on and into sidewalls of the trench at an intermediate region between the lower region and the upper region;
  - a dielectric layer formed along the sidewalls of the trench up to a level above the collar oxide; and

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- a second conductive region formed up to the level.
18. The trench capacitor of claim 17 further comprising a third conductive region formed over the second conductive region.
19. The trench capacitor of claim 17, the dielectric layer further including a nitride-oxide structure or an oxide-nitride-oxide structure.
20. The method of claim 17, the dielectric layer being formed along the sidewalls of the trench up to a top level of the collar oxide.

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